Storage Characteristics of Lithium Ion Cells

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Lithium ion cells are being developed under the NASA/Air Force Consortium for the upcoming aerospace missions. First among these missions are the Mars 2001 Lander and Mars 2003 Lander and Rover missions. Apart from the usual needs of high specific energy, energy density and long cycle life, a critical performance characteristic for the Mars missions is low temperature performance. The batteries need to perform well at –20°C, with at least 70% of the rated capacity realizable at moderate discharge rates (C/5). Several modifications have been made to the lithium ion chemistry, mainly with respect to the electrolyte, both at JPL[1] and elsewhere to achieve this.

Another key requirement for the battery is its storageability during pre-cruise and cruise periods. For the Mars programs, the cruise period is relatively short, about 12 months, compared to the Outer Planets missions (3-8 years). Yet, the initial results of our storage studies reveal that the cells do sustain noticeable permanent degradation under certain storage conditions, typically ~ of 10% over two months duration at ambient temperatures, attributed to impedance buildup.

The build up of the cell impedance or the decay in the cell capacity is affected by various storage parameters, i.e., storage temperature, storage duration, storage mode (open circuit, on buss or cycling at low rates) and state of charge. Our preliminary studies indicate that low storage temperatures and states of charge are preferable (Fig. 1). In some cases, we have observed permanent capacity losses of ~10% over eight-week storage at 40°C, compared to ~ 0-2% at 0°C. Also, we are attempting to determine the impact of cell chemistry and design upon the storageability of Li ion cells.

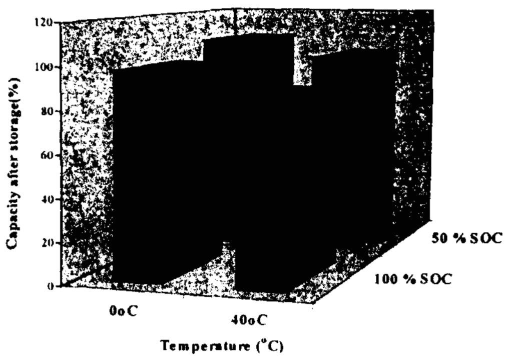

Fig. 1. Permanent capacity loss upon storage.

Subsequently, we have carried out design experimentation study with four parameters, i.e., temperature, storage period, and state of charge and storage mode, each of these parameters at three chosen values (levels). Reducing this to a L^9 matrix, nine tests were thus run to quantitatively understand their effect on the capacity degradation during storage. An analysis of the data reveals that both the storage temperature and storage period are the strongest parameters, compared to either state of charge or storage mode. The permanent capacity loss increases exponentially with the storage temperature (Fig. 2) and increases linearly with storage over six months (Fig. 3).

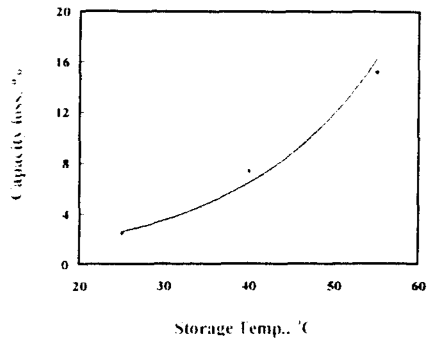

Fig. 2 Capacity loss vs. T during storage

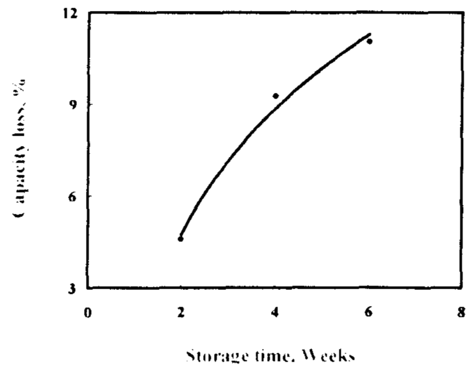

Fig. 3 Capacity loss during storage

The capacity loss is marginally reduced at low SOC's, but is affected by the mode of storage. Also, the degradation in performance becomes more pronounced in subsequent low temperature discharges (-20°C).

In this paper, we will present similar studies on different lithium ion cells, possibly with different electrolytes. For a further understanding of the phenomenon, we will present additional half-cell studies on the graphite electrodes as a function of electrolyte composition and temperature.

Acknowledgments

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References

1. M. C. Smart, B. V. Ratnakumar and S. Surampudi, *J. Electrochem. Soc.*, 146, 486 (1999) and references therein.